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【Title of the invention】 A braking control device of a vehicle

【Claims】

【Claim 1】

A braking control device of a vehicle adapted to conduct a front and rear braking force distribution control for lowering a braking pressure of rear wheels than that of front wheels when an operating condition of the vehicle becomes a predetermined condition and to increase the braking pressure of the front wheels based upon an increment of braking action of a driver when the braking action of the driver is increased after the start of the front and rear braking force distribution control, characterized in that when an auxiliary braking control is executed to increase the braking pressure to be higher than a braking pressure corresponding to the braking action of the driver, the braking pressure of the front wheels is increased based upon the increment of the braking action of the driver and the increment of the braking pressure by the auxiliary braking control.

【Claim 2】

A braking control device of a vehicle according to claim 1, wherein when the auxiliary braking control is not executed, the increment of the braking pressure of the front wheels is calculated based upon a difference between a current master cylinder pressure and a master cylinder pressure at the time of starting the front and rear braking force distribution control, and when the auxiliary braking force control is executed, the increment of the braking pressure of the front wheels is calculated based upon a difference between the current master cylinder pressure plus the increment of the braking pressure by the auxiliary braking control and the master cylinder pressure at the time of starting the front and rear braking force distribution control.

【Claim 3】

A braking control device of a vehicle according to claim 1 or 2, wherein when the increments of the braking pressures of the front and rear wheels by

the auxiliary braking control are different from one another, the increment of the braking pressure by the auxiliary braking control is made to be the increment of the braking pressure of the rear wheels to be increased by the auxiliary braking control.

【Claim 4】

A braking control device of a vehicle according to any one of claims 1-3, wherein the auxiliary braking control is a brake assist control executed when an urgent braking action was made by the driver.

【Detailed descriptions of the invention】

【0001】

【Technical field of the invention】

The present invention relates to a braking control device of a vehicle such as an automobile, and more particularly, to a braking control device of a vehicle for conducting a front and rear braking force distribution control.

【0002】

As one of the braking control devices of vehicles such as automobiles, there is conventionally known a braking control device adapted to hold or lower or pulsatively increase the braking pressure of the rear wheels when the operating condition of the vehicle becomes a predetermined condition, so as to execute a front and rear braking force distribution control for suppressing an increase of the braking force of the rear wheels.

【0003】

According to such a braking control device, it is prevented that the stability of the vehicle is deteriorated due to a locking of the rear wheels prior to the front wheels as compared with a case that no such front and rear braking force distribution control is executed, thereby improving the running stability of the vehicle. However, since the increase of the braking force of the rear wheels is suppressed by the execution of such a front and rear braking force distribution control, it can happen that in spite of an increase of the braking action by the driver desiring to increase the braking force, the braking force is

not sufficiently increased, giving the driver a feeling of discomfort in the braking action.

【0004】

In order to solve such a problem, there is described in, for example, the below-mentioned Patent document 1 based upon a patent application filed by the same applicant as the present applicant, a braking control device adapted to generate a braking force by supplying an operation fluid pressure of a master cylinder to wheel cylinders of braking force generation means provided at respective wheels and to execute a front and rear braking force distribution control for suppressing an increase of the braking force of the rear wheels when the driving condition of the vehicle becomes a predetermined condition, wherein the braking force of the front wheels is increased according to an extent of suppression of the braking force of the rear wheels when the front and rear braking force distribution control is executed.

【Patent document 1】

Specification and drawing of Patent Application 2001-360510

【0005】

【Problems to be solved by the invention】

According to the braking control device of the above-mentioned prior application, since the braking force of the front wheels is increased according to the extent of suppression of increase of the braking force of the rear wheels when the front and rear braking force distribution control is executed, a deficit of the braking force of the rear wheels due to the suppression of the increase of the braking force of the rear wheels during the execution of the front and rear braking force distribution control is certainly compensated for by an increase of the braking force of the front wheels, so that the whole braking force of the vehicle is effectively controlled to a braking force corresponding to the braking action of the driver, while definitely preventing that the rear wheels become a locked condition prior to the front wheels and the stability of the vehicle is thereby deteriorated.

【0006】

However, when the auxiliary braking control of increasing the braking pressure than that corresponding to the braking action of the driver as in a so called brake assist control and the front and rear braking force distribution control are executed at the same time, since not only the braking force of the rear wheels becomes insufficient due to the suppress of the increase of the braking force of the rear wheels but also the braking force of the rear wheels to be increased by the braking pressure of the auxiliary braking control becomes insufficient, when only the deficit of the braking force of the rear wheels due to the suppress of the increase of the braking force of the rear wheels is compensated for by an increase of the braking force of the front wheels, the compensation of the braking force becomes insufficient, thereby causing a problem that the whole braking force of the vehicle becomes insufficient and the braking effect of the auxiliary braking control lowers.

【0007】

The present invention was made in view of the above-mentioned problem in the conventional braking control device constructed to suppress an increase of the braking force of the rear wheels when the operating condition of the vehicle becomes a predetermined condition and to execute a front and rear braking force distribution control for increasing the braking force of the front wheels in accordance with the extent of suppressing the increase of the braking force of the rear wheels. A principal object of the present invention is to definitely prevent that the stability of the vehicle is deteriorated by the rear wheels becoming a locked condition prior to the front wheels thereby definitely ensuring the braking effect of the auxiliary braking device by precisely compensating the deficit of the braking force of the rear wheels by an increase of the braking force of the front wheels even when the front and rear braking force distribution control and the auxiliary braking control are executed at the same time by taking the increment of the braking pressure to be increased by the auxiliary braking control into consideration in the situation that the front

and rear braking force distribution control and the auxiliary braking control are executed at the same time.

【0008】

【Means to solve the problem】

According to the present invention, the above-mentioned object is accomplished by the construction of claim 1, i.e., a braking control device of a vehicle adapted to conduct a front and rear braking force distribution control for lowering a braking pressure of rear wheels than that of front wheels when an operating condition of the vehicle becomes a predetermined condition and to increase the braking pressure of the front wheels based upon an increment of a braking action of a driver when the braking action of the driver is increased after the start of the front and rear braking force distribution control, characterized in that when an auxiliary braking control is executed to increase the braking pressure to be higher than the braking pressure corresponding to the braking action of the driver, the braking pressure of the front wheels is increased based upon the increment of the braking action of the driver and the increment of the braking pressure by the auxiliary braking control.

【0009】

Further, according to the present invention, in order to effectively accomplish the above-mentioned principal object, in the construction of the above-mentioned claim 1, when the auxiliary braking control is not executed, the increment of the braking pressure of the front wheels is calculated based upon a difference between a current master cylinder pressure and a master cylinder pressure at the time of starting the front and rear braking force distribution control, and when the auxiliary braking force control is executed, the increment of the braking pressure of the front wheels is calculated based upon a difference between the current master cylinder pressure plus the increment of the braking pressure by the auxiliary braking control and the master cylinder pressure at the time of starting the front and rear braking force distribution control.

【0010】

Further, according to the present invention, in order to effectively accomplish the above-mentioned principal object, in the construction of claim 1 or 2, when the increments of the braking pressures of the front and rear wheels by the auxiliary braking control are different from one another, the increment of the braking pressure by the auxiliary braking control is made to be the increment of the braking pressure of the rear wheels to be increased by the auxiliary braking control.

【0011】

Further, according to the present invention, in order to effectively accomplish the above-mentioned principal object, in the construction of any of the above-mentioned claims 1-3, the auxiliary braking control is a brake assist control executed when an urgent braking action was made by the driver.

【0012】

【Functions and effects of the invention】

According to the construction of the above-mentioned claim 1, since the braking pressure of the front wheels is increased based upon the increment of the braking action of the driver and the increment of the braking pressure by the auxiliary braking control when the auxiliary braking control is executed so as to increase the braking pressure more than the braking pressure corresponding to the braking action of the driver, even in the condition that the front and rear braking force distribution control and the auxiliary braking control are executed at the same time, the deficit of the braking force of the rear wheels is more precisely compensated for by the increase of the braking force of the front wheels than in the case that the braking force of the front wheels is increased without taking the increment of the braking pressure by the auxiliary braking control into consideration, whereby the braking effect of the auxiliary braking control is definitely ensured, while preventing that the rear wheels get into a locked condition prior to the front wheels and the stability of the vehicle is thereby deteriorated.

【0013】

Further, according to the construction of claim 2, since the increment of the braking pressure of the front wheels is calculated based upon the difference between the current master cylinder pressure and the master cylinder pressure at the time of starting the front and rear braking force distribution control when the auxiliary braking control is not executed, while the increment of the braking pressure of the front wheels is calculated based upon the difference between the current master cylinder pressure plus the increment of the braking pressure by the auxiliary braking control and the master cylinder pressure at the time of starting the front and rear braking force distribution control when the auxiliary braking control is executed, the deficit of the braking pressure of the rear wheels can be precisely calculated, whereby the braking effect of the auxiliary control is definitely and precisely accomplished.

【0014】

Further, according to the construction of claim 3, since the increment of the braking pressure by the auxiliary braking control is the increment of the braking pressure of the front wheels to be increased by the auxiliary braking control when the increments of the braking pressures of the front and rear wheels by the auxiliary braking control are different from one another, the deficit of the braking force of the rear wheels is precisely compensated for by an increase of the braking force of the front wheels even when the increments of the braking pressures of the front and rear wheels by the auxiliary braking control are different from one another, whereby the braking effect of the auxiliary braking control is precisely and definitely ensured.

【0015】

Further, according to the construction of claim 4, since the auxiliary braking control is a brake assist control executed when an urgent braking action was made by the driver, the deficit of the braking force of the rear wheels is precisely compensated for by the increase of the braking force of the front wheels even in the case that the braking pressure is increased by the brake

assist control more than the braking pressure corresponding to the braking action of the driver, whereby the braking effect of the brake assist control is definitely ensured.

【0016】

【Preferred modes of the means for accomplishing the object】

According to a preferred mode of the present invention, in the constructions of the above-mentioned claims 1-4, the increase of the braking pressure of the rear wheels is suppressed when the operating condition of the vehicle becomes a predetermined condition, and the braking pressure of the front wheels is increased according to the extent of suppression of the increase of the braking pressure of the rear wheels when the front and rear braking force distribution control is executed. (Preferred mode 1)

【0017】

According to another preferred mode of the present invention, in the construction of the above-mentioned preferred mode 1, the front and rear braking force distribution control is executed by suppressing the increase of the wheel cylinder pressure of the rear wheels, the increment of the wheel cylinder pressure of the front wheels is calculated based upon the wheel cylinder pressure of the rear wheels and parameters expressing the braking performance of the braking force generation means of the front and rear wheels, and the wheel cylinder pressure of the front wheels is increased according to the increment. (Preferred mode 2)

【0018】

According to another preferred mode of the present invention, in the construction of the above-mentioned preferred mode 2, the parameter is such one that expresses the braking performance to be lower as the vehicle speed is higher. (Preferred mode 3)

【0019】

According to another preferred mode of the present invention, in the construction of the above-mentioned preferred mode 1, the braking control

device is so constructed as to variably set the extent of suppressing the increase of the braking pressure of the rear wheels according to the vehicle speed at the time point of the operating condition of the vehicle becoming a predetermined condition. (Preferred mode 4)

【0020】

According to another preferred mode of the present invention, in the construction of the above-mentioned preferred mode 1, the braking control device is so constructed as to variably set the extent of suppressing the increase of the braking force of the rear wheels according to the deceleration of the vehicle at the time of the operating condition of the vehicle becoming a predetermined condition. (Preferred mode 5)

【0021】

According to another preferred mode of the present invention, in the construction of the above-mentioned preferred mode 2, the increment of the wheel cylinder pressure of the front wheels is calculated based upon a difference between the master cylinder pressure and the wheel cylinder pressure of the rear wheels and a parameter expressing the braking performance of the braking force generation means of the front and rear wheels when the auxiliary braking control is not executed, while when the auxiliary braking control is executed, the increment of the wheel cylinder pressure of the front wheels is calculated based upon a difference between the master cylinder pressure plus the increment of the braking pressure and the wheel cylinder pressure of the rear wheels and a parameter expressing the braking performance of the braking force generation means of the front and rear wheels. (Preferred mode 6)

【0022】

According to another preferred mode of the present invention, in the construction of the above-mentioned preferred mode 2, the holding pressure of the rear wheels is set according to the running condition at the time point of the operating condition of the vehicle becoming the predetermined condition, and

the braking pressure of the rear wheels is maintained at the holding pressure. (Preferred mode 7)

【0023】

According to another preferred mode of the present invention, in the construction of the above-mentioned preferred mode 2, the master cylinder pressure at the time point of the operating condition of the vehicle becoming the predetermined condition is set to be the holding pressure of the rear wheels, and the braking pressure of the rear wheels is maintained at the holding pressure. (Preferred mode 8)

【0024】

According to another preferred mode of the present invention, in the construction of the above-mentioned preferred mode 3, the parameter includes a brake effectiveness coefficient of the braking force generation means. (Preferred mode 9)

【0025】

According to another preferred mode of the present invention, in the construction of the above-mentioned preferred mode 3, the brake effectiveness coefficient is estimated based upon the vehicle speed. (Preferred mode 10)

【0026】

【Embodiments of the invention】

In the following, the present invention will be described in detail with respect to the preferred embodiments (simply referred to as "embodiments" hereinunder) by referring to the accompanying drawings.

【0027】

Fig. 1 is a diagram of an oil hydraulic circuit and an electric control device of an embodiment of the braking control device according to the present invention, and Fig. 2 is a diagrammatic sectional view showing a communication control valve for the front wheels. In Fig. 1, the solenoids of the respective electromagnetically driven valves are omitted.

【0028】

Referring to Fig. 1, 10 designates an oil hydraulic braking device which comprises a master cylinder 14 for compressing a brake oil in response to a depressing operation of the brake pedal 12 by a driver. The master cylinder 14 has a first master cylinder chamber 14A and a second master cylinder chamber 14B divided by a free piston 16 biased to a predetermined position by compression coil springs provided on opposite sides thereof.

【0029】

The first master cylinder chamber 14A is connected with one end of a brake oil pressure control passage 18F for the front wheels, while the other end of the brake oil pressure control passage 18F is connected with each one end of a brake oil pressure control passage 20FL for the front left wheel and a brake oil pressure control passage 20FR for the front right wheel. At a middle portion of the brake oil pressure control passage 18F, there is mounted a communication control valve 22F for the front wheels, which is a normally open type linear solenoid valve in the shown embodiment. The communication control valve 22F is bypassed by a non return bypass passage 24F for allowing the oil to flow only from the first master cylinder chamber 14A to the brake oil pressure control passage 20FL or the brake oil pressure control passage 20FR.

【0030】

As shown diagrammatically in Fig. 2, the communication control valve 22F has a housing 72 defining a valve chamber 70 therein, with a valve element 74 arranged to be able to reciprocate in the valve chamber 70. The valve chamber 70 is always in communication with the part 18FA of the brake oil pressure control passage 18F on the side of the master cylinder 14, while the portion 18FB of the brake oil pressure control passage 18F on the side opposite to the master cylinder 14 is connected with the valve chamber 70 via an internal passage 78 and a port 80.

【0031】

As shown in the figure, a solenoid 82 is arranged around the valve element 74 which is biased to a valve opening position such as shown in Fig. 2

by a compression coil spring 84. When the solenoid 82 is energized, the valve element 74 is driven toward the port 80 against the spring force of the compression coil spring 84, so as to close the port 80.

【0032】

With the communication control valve 22F being in its closed condition, when the sum of the force due to the pressure in the portion 18FB of the brake oil pressure control passage 18F on the side opposite to the master cylinder 14 and the spring force of the compression coil spring 84 becomes larger than the electromagnetic force, the valve element 74 departs from the port 80 so as to open the port, whereby the oil in the portion 18FB flows toward the portion 18FA of the brake oil pressure control passage 18F through the internal passage 74, port 80, valve chamber 70 and internal passage 76. Then, when the oil pressure in the portion 18FB lowers as a result of this flow, the sum of the force due to the pressure and the spring force of the compression coil spring 84 becomes smaller than the electromagnetic force by the solenoid 82, whereby the valve element 74 closes again the port 80.

【0033】

Thus, the communication control valve 22F controls the pressure in the portion 18FB of the brake oil pressure control passage 18F according to the voltage charged to the solenoid 82, so that by the control of the driving voltage to the solenoid 82 the pressure in the portion 18FB (referred to as "upstream pressure" in this specification) is controlled to a desired pressure by the communication control valve 22F.

【0034】

In the shown embodiment, the non return bypass passage 24F shown in Fig. 1 is incorporated in the communication control valve 22F, so as to be constructed by an internal passage 86 and a non return valve 88 provided in the internal passage to allow the oil to flow only from the valve chamber 70 toward the portion 18FB.

【0035】

The other ends of the brake oil pressure control passage 20FL for the front left wheel and the brake oil pressure control passage 20FR for the front right wheel are connected with wheel cylinders 26FL and 26FR, respectively, of the braking force generation means not shown in the figure for generating the braking forces for the front left wheel and the front right wheel. Normally open type electromagnetic on-off valves 28FL and 28FR are provided at a middle portion of each of the brake oil pressure control passage 20FL for the front left wheel and the brake oil pressure control passage 20FR for the front right wheel. The electromagnetic on-off valves 28FL and 28FR are respectively bypassed by non-return bypass passages 30FL and 30FR for allowing the oil to flow only from the wheel cylinders 26FL and 26FR toward the brake oil pressure control passage 18F.

【0036】

An oil exhaust passage 32FL is connected at one end thereof to the brake oil pressure control passage 20FL at a portion thereof between the electromagnetic on-off valve 28FL and the wheel cylinder 26FL, while an oil exhaust passage 32FR is connected an one end thereof to the brake oil pressure control passage 20FR at a portion thereof between the electromagnetic on-off valve 28FR and the wheel cylinder 26FR. Normally closed type electromagnetic on-off valves 26FL and 26FR are provided at a middle portion of each of the oil exhaust passages 32FL and 32FR, the other ends of which are connected with a buffer reservoir 38F by a connecting passage 36F.

【0037】

As will be understood from the above descriptions, the electromagnetic on-off valves 28FL and 28FR are the valves for increasing or maintaining the pressures in the wheel cylinders 26FL and 26FR, respectively, while the electromagnetic on-off valves 34FL and 34FR are the valves for decreasing the pressures in the wheel cylinders 26FL and 26FR, respectively. Therefore, the electromagnetic on-off valves 28FL and 34FL in combination construct a pressure control means for increasing, decreasing or maintaining the pressure

in the wheel cylinder 26FL for the front left wheel, while the electromagnetic on-off valves 28FR and 34FR in combination construct a pressure control means for increasing, decreasing or maintaining the pressure in the wheel cylinder 26FR for the front right wheel.

【0038】

The connecting passage 36F is connected with an inlet side of a pump 42F by a connecting passage 40F, and two non-return valves 44F and 46F are provided in the way of the connecting passage 40F so as to allow the oil to flow only from the connecting passage 36F toward to the pump 42F. The outlet side of the pump 42F is connected with the brake oil pressure control passage 18F by a connecting passage 50F including a damper 48F in the way thereof. A non-return valve 42F is provided at a portion of the connecting passage 50F between the pump 42F and the damper 48F to allow the oil to flow only from the pump 42F toward the damper 48F.

【0039】

One end of a connecting passage 54F is connected to a portion of the connecting passage 40F between the two non-return valves 44F and 46F, the other end of which is connected with a portion of the brake oil pressure control passage 18F between the first master cylinder chamber 14A and the control valve 22F. A normally closed type electromagnetic on-off valve 60F is provided in the way of the connecting passage 54F. The electromagnetic on-off valve 60F operates as a suction control valve for controlling a communication between a portion of the brake oil pressure control passage 18F between the master cylinder 14 and the control valve 22F and the inlet side of the pump 42F.

【0040】

Similarly, one end of a brake oil pressure control passage 18R for the rear wheels is connected to the second master cylinder chamber 14B, while the other end of the brake oil pressure control passage 18R is connected with each one end of a brake oil pressure control passage 20RL for the rear left wheel and

a brake oil pressure control passage 20RR for the rear right wheel. At a middle portion of the brake oil pressure control passage 18R there is provided a communication control valve 22R for the rear wheels which is constructed as a normally closed type linear solenoid valve.

【0041】

The communication control valve 22R has the same construction as the communication control valve 22F for the front wheels illustrated in Fig. 2. Therefore, by a driving voltage for the solenoid thereof not shown in the figure being controlled, the pressure in the brake oil pressure control passage 18R at the downstream side of the communication control valve 22R is controlled to a required pressure. Portions of the brake oil pressure control passage 18R located at the opposite sides of the communication control valve 22R are connected by a non-return bypass passage 24R which allows the oil to flow only from the second master cylinder 14B toward the brake oil pressure control passage 20RL or the brake oil pressure control passage 20RR.

【0042】

The other end of the brake oil pressure control passage 20RL for the rear left wheel and the brake oil pressure control passage 20RR for the rear right wheel are connected with wheel cylinders 26RL and 26RR of the braking force generation means not shown in Fig. 1 for generating the braking forces for the rear left wheel and the rear right wheel, respectively. Normally open type electromagnetic on-off valves 28RL and 28RR are provided in the way of the brake oil pressure control passage 20RL for the rear left wheel and the brake oil pressure control passage 20RR for the rear right wheel, respectively. Portions of the brake oil pressure control passages 20RL and 20RR located at opposite sides of the electromagnetic on-off valves 28RL and 28RR are connected by non-return bypass passages 30RL and 30RR, respectively, for allowing the oil to flow only from the wheel cylinders 26RL and 26RR toward the brake oil pressure control passage 18R.

【0043】

One end of an oil exhaust passage 32RL is connected to a portion of the brake oil pressure control passage 20RL located between the electromagnetic on-off valve 28RL and the wheel cylinder 26RL, and one end of an oil exhaust passage 32RR is connected to a portion of the brake oil pressure control passage 20RR located between the electromagnetic on-off valve 28RR and the wheel cylinder 26RR. Normally closed type electromagnetic on-off valves 34RL and 34RR are provided in the way of the oil exhaust passages 32RL and 32RR, respectively, while the other ends of the oil exhaust passages 32RL and 32RR are connected to a buffer reservoir 38R by a connecting passage 36R.

【0044】

In the same manner as for the front wheels, the electromagnetic on-off valves 28RL and 28RR are the valves for increasing or maintaining the pressures in the wheel cylinders 26RL and 26RR, while the electromagnetic on-off valves 34RL and 34RR are the valves for decreasing the pressures in the wheel cylinders 26RL and 26RR. Therefore, the electromagnetic on-off valves 28RL and 34RL in combination construct a control valve for increasing, decreasing or maintaining the pressure in the wheel cylinder 26RL for the rear left wheel, while the electromagnetic on-off valves 28RR and 34RR in combination construct a control valve for increasing, decreasing or maintaining the pressure in the wheel cylinder 26RR for the rear right wheel.

【0045】

A connecting passage 36R is connected to the intake side of a pump 42R by a connecting passage 40R, and two non-return valves 44R and 46R are provided in the way of the connecting passage 40R to allow the oil to flow only from the connecting passage 36R toward the pump 42R. The outlet side of the pump 42R is connected with the brake oil pressure control passage 18R by a connecting passage 50R having a damper 48R in the way thereof. A non-return valve 52R is provided in the connecting passage 50R at a portion between the pump 42R and the damper 48R for allowing the oil to flow only from the pump 42R toward the damper 48R. The pumps 42F and 42R are

driven by a common electric motor not shown in Fig. 1.

【0046】

One end of a connecting passage 54R is connected to a portion of the connecting passage 40R located between the two non-return valves 44R and 46R, while the other end of the connecting passage 54R is connected with a portion of the brake oil pressure control passage 18R located between the second master cylinder chamber 14B and the control valve 22R. A normally closed type electromagnetic on-off valve 60R is provided in the way of the connecting passage 54R. The electromagnetic on-off valve 60R also operates as an intake control valve for controlling the communication between a portion of the brake oil pressure control passage 18R located between the master cylinder 14 and the control valve 22R and the inlet side of the pump 42R.

【0047】

In the shown embodiment, the control valves and the on-off valves are set at the non-controlling positions shown in Fig. 1 when no driving electric current is supplied to the solenoids thereof, whereby the wheel cylinders 26FL and 26FR are supplied with the pressure of the first master cylinder chamber 14A, and the wheel cylinders 26RL and 26RR are supplied with the pressure of the second master cylinder chamber 14B. Therefore, in the normal operation, the pressures in the wheel cylinders of the respective wheels, i.e. the braking forces of the respective wheels are increased according to a depression of the brake pedal 12.

【0048】

In contrast, when the communication control valves 22F and 22R are changed over to their closed position, the on-off valves 60F and 60R are opened, and the pumps 42F and 42R are driven with the on-off valves for the respective wheels being positioned as shown in Fig. 1, the oil in the master cylinder 14 is pumped by the pumps, so that the wheel cylinders 26FL and 26FR are supplied with the oil pressurized by the pump 42F, while the wheel cylinders 26RL and 26RR are supplied with the oil pressurized by the pump 42R, whereby the

braking pressures for the respective wheels are controlled according to opening or closing of the communication control valves 22F and 22R and the on-off valves for respective wheels regardless of the depression of the brake pedal 12.

【0049】

In this case, the pressures in the wheel cylinders are increased when the on-off valves 28FL-28RR and the on-off valves 34FL and 34RR are in the non-controlling position as shown in Fig. 1 (pressure increasing mode), maintained at fixed pressures when the on-off valves 28FL-28RR are changed over to the closed position with the on-off valves 34FL-34RR being at the non-controlled position shown in Fig. 1 (holding mode), and decreased when the on-off valves 28FL-28RR and the on-off valves 34FL-34RR are changed over to the open position (pressure decreasing mode).

【0050】

The communication control valves 22F and 22R, the on-off valves 28Fl-28RR, the on-off valves 34FL-34RR and the on-off valves 60F and 60R are controlled by an electronic control device 90 as described hereinunder. The electronic control device 90 is composed of a micro computer 92 and a driving circuit 94, wherein the micro computer 92 may be of a common construction well known in this art.

【0051】

The micro computer 92 is supplied with a signal indicating master cylinder pressure Pm from a pressure sensor 96, a signal indicating vehicle speed V from a vehicle speed sensor 98, and a signal indicating longitudinal acceleration Gx of the vehicle from a longitudinal acceleration sensor 100. The micro computer 92 is loaded with a control flow described hereinunder, calculates target control pressures Pti (i = fl, fr, rl, rr) for the front left and right and rear left and right wheels, and controls the braking pressures Pi (i = fl, fr, rl, rr) of the respective wheels to the target braking pressures Pti by controlling the communication control valve 22F and others.

【0052】

Particularly in the shown embodiment, when the braking action by the driver is small so that no front and rear braking force distribution control is required, the communication control valve 22F and others are maintained in their standard positions shown in the figure, with the pumps 42F and 42R being not driven, whereby the braking pressures for the respective wheels, i.e. the pressures in the wheel cylinders 26FL-26RR are controlled according to the master cylinder pressure Pm.

【0053】

In contrast, when the braking action by the driver is large so that the front and rear braking force distribution control is required, first the communication control valves 22F and 22R are closed, then the intake control valves 60F and 60R are opened, and thereafter the pumps 42F and 42R are started to be driven, and the holding pressure Pc for the rear wheels is calculated based upon the vehicle speed V and the deceleration of the vehicle Gxb (= -Gx) as described in detail hereinunder, then the pressure increment ΔPf for the front wheels is calculated based upon the master cylinder pressure Pm, the holding pressure Pc for the rear wheels, etc., then the upstream pressure for the front wheels is controlled to become a target control pressure such as Pm + ΔPf by the control of the communication control valve 22F, and then the rear wheel system is controlled by closing the on-off valves 28RL and 28RR for the rear left and right wheels so that the braking pressures for the rear left and right wheels become the holding pressure Pc.

【0054】

Further in the shown embodiment, when the rate of braking action by the driver is high according to an urgent braking action by the driver, when, for example, the master cylinder pressure Pm is higher than a standard value therefor with the change rate of the master cylinder pressure Pm being higher than a standard value determined therefor, the ratio of the braking pressure for the respective wheels is increased relative to the master cylinder pressure Pm in the normal condition, so that the braking effect is increased by a brake assist

control according to the auxiliary braking control for assisting the braking action by the driver.

【0055】

Further in the shown embodiment, when the front and rear braking force distribution control is executed in the condition that the brake assist control is not executed, the pressure increase ΔPf for the front wheels by the front and rear braking force distribution control is calculated based upon a difference between the master cylinder pressure Pm and the holding pressure Pc for the rear wheels, while when the front and rear braking force distribution control is executed in the condition that the braking force is increased from the master cylinder pressure Pm by the brake assist control, the pressure increment ΔPf for the front wheels by the front and rear braking force distribution control is calculated based upon the difference between the master cylinder pressure Pm + pressure increment ΔPba of the braking pressure due to the brake assist control and the holding pressure Pc for the rear wheels.

【0056】

Further, when the front and rear braking force distribution control is executed in the condition that the braking pressure is increased from the master cylinder pressure Pm by the brake assist control, the braking pressure for the front wheels is controlled to be Pm + ΔPf + ΔPba, and the braking pressure for the rear wheels is controlled to be the same holding pressure Pc as in the case that the brake assist control is not executed.

【0057】

Although not shown in the figure, the electromagnetic on-off valves 28FL-28RR and the on-off valves 34FL-34RR are also controlled to stabilize the behavior of the vehicle by controlling the braking forces of the respective wheels separately.

【0058】

In the following, the braking control routine by the shown embodiment will be described by referring to the flowchart in Fig. 3. The control according

to the flowchart shown in Fig. 3 is started by a closing of an ignition switch not shown in the figure, and is repeatedly executed with a predetermined timing.

【0059】

First, in step 10, signals indicating the master cylinder pressure Pm detected by the pressure sensor 96 and others are read in, and in step 20 it is judged if the front and rear braking force distribution control is being executed, i.e., if it is the condition that the answer of the below-mentioned step 30 is yes and the answer of step 85 is no. When the answer is yes, the control proceeds to step 85, whereas when the answer is no, the control proceeds to step 30.

【0060】

In step 30, the basic holding pressure Pcs for the rear wheels is calculated according to the vehicle speed V by referring to a map such as shown in Fig. 4, then in step 40 a pressure compensation ΔPc for the basic holding pressure Pcs is calculated based upon the deceleration Gxb of the vehicle by referring to a map such as shown in Fig. 5, and then in step 50 the holding pressure Pc for the rear wheels is calculated as a sum of the basic holding pressure Pcs and the pressure compensation ΔPc. In Fig. 5, Gxbo is a standard deceleration of the vehicle during a braking condition of the vehicle.

【0061】

In step 60, it is judged if the master cylinder pressure Pm is higher than the holding pressure Pc of the rear wheels, i.e., if it is required to increase the braking pressure of the front wheels while holding the braking pressure of the rear wheels. When the answer is no, the control proceeds to step 70, whereas when the answer is yes, the control proceeds to step 100.

【0062】

In step 70, it is judged if other conditions for starting the front and rear braking force distribution control are established by any manner known in this art. When the answer is no, the control according to this routine is once ended, whereas when the answer is yes, the control proceeds to step 80, wherein the holding pressure Pc for the rear wheels is set to the current master cylinder

pressure Pm. Then the control proceeds to step 100.

【0063】

The judgment if the other conditions for starting the front and rear braking force distribution control may be made by judging, for example, (A) a difference ΔVw of a mean value Vwr of the wheel speeds of the rear left and rear right wheels relative to a mean value Vwf of the wheel speeds of the front left and front right wheels is larger than a standard value Vws (positive constant) for starting the control, or (B) if the deceleration Gxb of the vehicle is larger than a standard value Gxs (positive constant) for starting the control, or the judgment may be made by a combination of the conditions (A) and (B). Or the routine may be modified such that it is judged at the same time if the conditions for starting the control of steps 60 and 70 are established, and when the answer in the first judgment is yes, the control proceeds to step 80, and when the answer in the second judgment is yes, the control proceeds to step 100, whereas when the answer is no, the control according to the routine of Fig. 3 is ended.

【0064】

In step 85, it is judged if the condition for ending the front and rear braking force distribution control is established by judging, for example, if the master cylinder pressure Pm has lowered below a standard value Pme (a positive constant smaller than Pc), and when the answer is yes, the control according to the routine is once ended, whereas when the answer is no, the control proceeds to step 90.

【0065】

The judgment for checking if the conditions for ending the front and rear braking force distribution control have been established or not may be made according to any manner known in this art. When the judgment for checking the establishment of the conditions for starting the control is made by, for example, the difference ΔVw of the wheel speeds, the judgment for checking the establishment of the conditions for ending the control may be made by

checking if the difference ΔVw has lowered below a standard value Vwe (a positive constant smaller than Vs) for ending the control. Or, when the establishment of the conditions for starting the control is made based upon the deceleration Gxb of the vehicle, the judgment for checking the establishment of the conditions for ending the control may be made by checking if the deceleration Gxb of the vehicle has lowered below a standard value Gxe (a positive constant smaller than Gxs) for ending the control.

【0066】

In step 90, it is judged if the brake assist control is being executed, and when the answer is no, the control proceeds to step 100, whereas when the answer is yes, i.e., when the front and rear braking force distribution control and the brake assist control are both executed, the control proceeds to step 105.

【0067】

In step 100, denoting sectional areas of the wheel cylinders for the front and rear wheels as Sf and Sr (positive constants), respectively, braking effective radii of the front and rear wheels as Rf and Rr (positive constants), respectively, and braking effectiveness coefficient of the front and rear wheels as BEFf and BEFr (positive constants), respectively, a coefficient Kb is calculated according to the below-mentioned formula 1, and a basic pressure increment ΔPfo of the braking pressure for the front wheels is calculated according to the below-mentioned formula 2. The sectional areas Sf and Sr of the wheel cylinders and the braking effectiveness radii Rf and Rr are those values determined according to the particulars of the braking force generation means, while the braking effectiveness coefficients BEFf and BEFr may be obtained by, for example, experiments.

$$Kb = (Sr \times Rr \times BEFr)/(Sf \times Rf \times BEFf) \quad ...(1)$$

$$\Delta Pfo = (Pm - Pc)\,Kb \quad ...(2)$$

【0068】

In step 105, the coefficient Kb is calculated according to the above-mentioned formula 1, and the basic pressure increment ΔPfo of the

braking pressure for the front wheels is calculated according to the below-mentioned formula 3, wherein ΔPba is the braking pressure increment by the brake assist control.

$$\Delta Pfo = (Pm + \Delta Pba - Pc)\, Kb \qquad ...(3)$$

【0069】

In step 110, the braking effectiveness coefficient BEFv corresponding to the current vehicle speed is calculated based upon the vehicle speed V by referring to a map such as shown in Fig. 6, and a difference ΔBEF (= BEFo − BEFv) is calculated as a difference between the standard braking effectiveness coefficient BEFo and the current braking effectiveness coefficient BEFv, and further an increment ΔPf of the braking pressure for the front wheels is calculated according to the below-mentioned formula 4. A map such as shown in Fig. 3 may be provisionally obtained by, for example, experiments.

$$\Delta Pf = \Delta Pfo\,(1 + \Delta BEF/BEFo) \qquad ...(4)$$

【0070】

In step 120, it is judged if the brake assist control is being executed, and when the answer is yes, the control proceeds to step 140, whereas when the answer is no, the control proceeds to step 130, wherein the increment ΔPba of the braking pressure for the front wheels by the brake assist control used in the calculation of the basic increment ΔPfo of the braking pressure for the front wheels in the below-mentioned step 140 is reset to zero.

【0071】

In step 140, target braking pressures Ptfl and Ptfr for the front left and front right wheels are calculated as a sum of the master cylinder pressure Pm, the pressure increment ΔPf and the pressure increment ΔPba of the braking pressure of the front wheels by the brake assist control, and the front wheel control system of the braking device 10 is controlled so that the braking pressures of the front left and front right wheels become the target braking pressures Ptfl and Ptfr, respectively. Then in step 150, the target braking pressures Ptrl and Ptrr for the rear left and rear right wheels are set to the

holding pressure Pc, and the rear wheel control system of the braking device 10 is controlled so that the braking pressures of the rear left and rear right wheels become the target braking pressures Ptrl and Ptrr, respectively.

【0072】

Although not shown in Fig. 3, when the answer of step 70 is no, and the answer of step 90 is yes, the communication control valve 22F and others are set to the standard positions shown in Fig. 1, whereby the wheel cylinders 26FR-26RR of the respective wheels are directly supplied with the pressure Pm of the master cylinder 14, so that the braking pressures of the respective wheels are controlled according to the braking action of the driver.

【0073】

Thus, according to the shown embodiment, when the front and rear braking force distribution control for the front and rear wheels are not executed, the answer of step 20 is no, then in step 30 the basic holding pressure Pcs for the rear wheels is calculated based upon the vehicle speed V, then in step 40 the pressure compensation ΔPc for the basic holding pressure Pcs is calculated based upon the deceleration Gxb of the vehicle, and then in step 50 the holding pressure Pc of the rear wheels is calculated as a sum of the basic holding pressure Pcs and the pressure compensation ΔPc.

【0074】

When the master cylinder pressure Pm is lower than the holding pressure Pc of the rear wheels, and other conditions for starting the front and rear braking force distribution control are not established, the suppression of the braking force of the rear wheels is not required, and therefore the answers of steps 60 and 70 are no, and the wheel cylinders 26FL and 26RR of the front and rear wheels are supplied with the pressure in the master cylinder 14, and therefore the control for suppressing the braking pressure of the rear wheels and the control for increasing the braking pressure of the front wheels are not executed.

【0075】

In contrast, when the braking action of the driver is increased, so that the master cylinder pressure Pm exceeds the holding pressure Pc for the rear wheels, the answer of step 60 becomes yes, or even when the master cylinder pressure Pm is no higher than the holding pressure Pc for the rear wheels but the other conditions for starting the front and rear braking force distribution control are established, then the answer of step 70 becomes yes, then in step 80 the holding pressure Pc for the rear wheels is set to the current master cylinder pressure Pm, and then in step 100 the basic pressure increment ΔPfo of the braking pressure for the front wheels is calculated based upon the difference Pm − Pc between the master cylinder pressure Pm and the holding pressure Pc of the rear wheels, and then in step 110 the braking effectiveness coefficient BEFv corresponding to the current vehicle speed is calculated based upon the vehicle speed V, then the difference ΔBEF between the standard braking effectiveness coefficient BEFo and the current braking effectiveness coefficient BEFv is calculated, and then the pressure increment ΔPf of the braking pressure for the front wheels is calculated according to the above-mentioned formula 3.

【0076】

Further in step 140, the front wheel control system of the braking device 10 is controlled so that the braking pressures of the front left and front right wheels become the target braking pressures Ptfl and Ptfr calculated as the sum of the master cylinder pressure Pm, the pressure increment ΔPf and the pressure increment ΔPfba of the braking pressure of the front wheels by the brake assist control (0 when the brake assist control is not executed), and then in step 150 the rear wheel control system of the braking device 10 is controlled so that the braking pressures of the rear left and rear right wheels become the target braking pressures Ptrl and Ptrr = holding pressure Pc.

【0077】

Therefore, according to the shown embodiment, when the conditions for starting the front and rear braking force distribution control were established, until the conditions for ending the front and rear braking force

distribution control were established, when the master cylinder pressure Pm is higher than the holding pressure Pc for the rear wheels, the braking pressure of the rear wheels is maintained at the holding pressure Pc, so that it is definitely prevented that the rear wheels get into a locked condition prior to the front wheels, while the pressure increment ΔPf of the braking pressure of the front wheels corresponding to the deficit of the braking force due to the braking pressure of the rear wheels being maintained at the holding pressure Pc is calculated, and the braking pressure of the front wheels is increased as much as ΔPf, so as to compensate for the deficit of the whole braking force of the vehicle due to the braking pressure of the rear wheels being held by the increase of the braking force of the front wheels, whereby the braking force as a whole of the vehicle is definitely controlled to the braking force corresponding to the braking action of the driver even when the front and rear braking force distribution control is executed.

【0078】

Fig. 7 shows the relationship between the braking force Fbf of the front wheels and the braking force Fbr of the rear wheels in the shown embodiment, wherein the two dots and dash line shows an ideal distribution between the front and rear wheels, while the solid line shows the front and rear distribution according to the shown embodiment. As shown in the figure, in the range where the braking force Fbf of the front wheels is lower than the braking force Fbfc corresponding to the holding pressure Pc of the rear wheels, the braking force Fbf of the front wheels and the braking force Fbr of the rear wheels increase at a constant rate relative to one another according to an increase of the master cylinder pressure Pm, while in the range where the braking force Fbf of the front wheels is larger than the braking force Fbfc corresponding to the holding pressure Pc of the rear wheels, the braking force Fbr of the rear wheels is maintained at the braking force Fbrc corresponding to the holding pressure Pc so that the actual front and rear distribution of the braking force does not exceed the ideal front and rear distribution line.

【0079】

Fig. 8 shows the relationship between the master cylinder pressure Pm and the braking pressure Pf of the front wheels and the braking pressure Pr of the rear wheels by the shown embodiment, wherein the two dots and dash line shows the relationship between the master cylinder pressure Pm and the braking pressure Pf of the front wheels and the braking pressure Pr of the rear wheels when the front and rear braking force distribution control is not executed.

【0080】

As shown in Fig. 8, in a range where the master cylinder pressure Pm is lower than the holding pressure Pc, the braking pressure Pf of the front wheels and the braking pressure Pr of the rear wheels are the master cylinder pressure Pm and the same with one another, and in a range where the master cylinder pressure Pm is larger than the holding pressure Pc, the braking pressure Pr of the rear wheels is the holding pressure Pc (constant), so that expressing the current master cylinder pressure Pm by Pma, a pressure increment ΔPf of the braking pressure of the front wheels corresponding to the extent of suppression of the braking force of the rear wheels corresponding to the suppression amount ΔPr (= Pma − Pc) of the braking pressure of the rear wheels is calculated, and the braking pressure Pf of the front wheels is controlled to be Pma + ΔP.

【0081】

Further, according to the shown embodiment, when the front and rear braking force distribution control is executed in the condition that the brake assist control is not executed, the answers of steps 85 and 90 are no, and in step 100 the pressure increment ΔPf of the front wheels of the front and rear distribution control is calculated based upon the difference between the master cylinder pressure Pm and the holding pressure Pc of the rear wheels, while when the front and rear braking force distribution control is executed in a condition that the braking pressure of the wheels is increased to be larger than

the master cylinder pressure Pm by the brake assist control, the answers of steps 85 and 90 are no and yes, respectively, and the pressure increment ΔPf of the front wheels of the front and rear distribution control is calculated in step 105 according to the above-mentioned formula 2 based upon the difference between "master cylinder pressure Pm + pressure increment ΔPba of the braking pressure by the brake assist control" and the holding pressure Pc of the rear wheels.

【0082】

Therefore, as compared to such a case that the pressure increment ΔPf of the front wheels is calculated without taking the pressure increment ΔPba of the braking pressure by the brake assist control into consideration even when the front and rear braking force distribution control and the brake assist control are executed at the same time, the deficit of the braking force of the rear wheels is precisely compensated for by an increase of the braking force of the front wheels, whereby the braking effect of the brake assist control is definitely ensured, while definitely preventing that the rear wheels get into a locked condition prior to the front wheels and the stability of the vehicle is thereby deteriorated.

【0083】

Fig. 9 shows diagrammatically the variations of the braking pressures of the front and rear wheels under a simplified condition that the coefficient Kb is 1 with respect to the shown embodiment (A) and the conventional braking control device not taking the increment of the braking pressure to be increased by the brake assist control into consideration (B). In Fig. 9, the hatching inclining from upper right to lower left shows the pressure of the master cylinder pressure Pm exceeding the holding pressure Pc, and the hatching inclining from upper left to lower right shows the braking pressure Δ Pba to be increased by the brake assist control.

【0084】

As shown by Fig. 9 (A), in the case of the shown embodiment, the

pressure Pm − Pc of the master cylinder pressure Pm exceeding the holding pressure Pc by the front and rear braking force distribution control is transferred from the rear wheels to the front wheels by the longitudinal transfer (1), and also the braking pressure ΔPba to be increased by the brake assist control is transferred from the rear wheels by the longitudinal transfer (2), so that in both cases of the front and rear braking force distribution control being not executed and executed, the total braking pressure of the vehicle is 4(Pm+ ΔPa), thus definitely accomplishing the purposes of the brake assist control and the front and rear braking force distribution control.

【0085】

In contrast, as shown by Fig. 9(B), in the case of the conventional braking control device, although the pressure Pm − Pc of the master cylinder pressure Pm exceeding the holding pressure Pc by the front and rear braking force distribution control is transferred from the rear wheels to the front wheels by the longitudinal transfer (1), the longitudinal transfer (2) is not executed, so that the braking pressure ΔPba to be increased by the brake assist control is not transferred from the rear wheels to the front wheels, with the braking force of the rear wheels being controlled to the holding pressure Pc, so that when the front and rear braking force distribution is executed, the whole braking pressure of the vehicle is 4Pc + 4(Pm− Pc) + 2(ΔPa) = 4Pm + 2ΔPba, causing a deficit of the braking force corresponding to the braking pressure of 2ΔPba, rendering the objects of the brake assist control and the front and rear braking force distribution control being not accomplished.

【0086】

Particularly according to the shown embodiment, the increment ΔPf of the braking pressure of the front wheels is not simply set to the amount of suppression ΔPr of the braking pressure of the rear wheels, but is calculated as a value to be added to the braking force of the front wheels as the braking force corresponding to the deficit of the braking force of the rear wheels due to the suppression of the braking pressure of the rear wheels, and therefore, as

compared with the case that the braking pressure of the front wheels is set to the master cylinder pressure Pma + the suppression amount ΔPr of the braking pressure of the rear wheels, the whole braking force of the vehicle is controlled to a value precisely corresponding to the braking action of the driver.

【0087】

Since the braking effect of the front wheels generally lowers as compared with that of the rear wheels according to increase of the vehicle speed, so that the front and rear braking force distribution control is shifted rearward as a result, so that it is desirable that the holding pressure Pc of the rear wheels is set lower according to increase of the vehicle speed. Further, since the ideal front and rear braking force distribution generally shifts rearward according to increase of the load of the vehicle, while the deceleration of the vehicle lowers according to increase of the load of the vehicle so that the front wheels need to bear more braking force, it is desirable that the holding pressure Pc of the rear wheels is set to be higher as the deceleration of the vehicle at the starting of the front and rear braking force distribution control is lower.

【0088】

According to the shown embodiment, the holding pressure Pc is not set at a constant value, but is variably set in steps 30-50 according to the vehicle speed V and the deceleration Gxb of the vehicle so as to be smaller as the vehicle speed is higher and to be smaller as the deceleration is higher, and therefore, as compared with the case that the vehicle speed or the deceleration of the vehicle is not taken into consideration, the holding pressure Pc of the rear wheels is set properly, so that the front and rear braking force distribution control is executed properly according to the operating condition of the vehicle.

【0089】

Further, according to the shown embodiment, since the increment ΔPf of the braking pressure of the front wheels is calculated in step 110 by taking into consideration that the braking effectiveness coefficient BEF lowers according to increase of vehicle speed, the increment ΔPf of the braking

pressure of the front wheels is calculated to more precisely correspond to the deficit of the braking force of the rear wheels as compared with a case that no such consideration is made, whereby the braking pressure of the front wheels is properly controlled with no surplus or deficit.

【0090】

Although the present invention has been described in detail with respect to a particular embodiment, it will be apparent for those skilled in the art that the present invention is not restricted to the shown embodiment, but the invention can be carried out in other various embodiments within the scope of the invention.

【0091】

For example, although in the shown embodiment the auxiliary braking control for increasing the braking pressure to be higher than that corresponding to the braking action of the driver is the brake assist control executed in response to an urgent braking action of the driver, the auxiliary braking control may be a control to increase the ratio of the braking pressure relative to the braking action when the amount of braking action of the driver is large.

【0092】

Further, although in the shown embodiment the increment ΔPba of the braking pressure of the front and rear wheels increased by the brake assist control is the same for the front and rear wheels, when the increment of the braking pressure of the front and rear wheels increased by the brake assist control are different from one another, the increment of the braking pressure of the rear wheels increased by the brake assist control is transferred from the rear wheels to the front wheels. For example, denoting the increment of the braking pressure of the front and rear wheels increased by the brake assist control as $\Delta Pbaf$ and $\Delta Pbar$, respectively, the above-mentioned formula 2 is changed to the below-mentioned formula 5, and in step 140 the target braking pressures Ptfl and Ptfr of the front left and front right wheels are calculated as a sum of the master cylinder pressure Pm, the pressure increment ΔPf, increment

ΔPba of the braking pressure of the front wheels by the brake assist control, and increment ΔPbaf of the braking pressure of the front wheels increased by the brake assist control.

$$\Delta Pfo = (Pm + \Delta Pbar - Pc)\,Kb \qquad ...(5)$$

【0093】

Further, although in the shown embodiment the amount of the braking action of the driver is obtained from the master cylinder pressure Pm, it may be the stroke of the brake pedal 26 or the depression force of the brake pedal 26, or it may be an optional combination of these parameters.

【0094】

Further, although in the shown embodiment the holding pressure Pc of the rear wheels is set to be constant until the conditions for ending the front and rear braking force distribution control are established, the braking pressure of the rear wheels may be gradually lowered or steppedly or gradually increased by the holding pressure Pc being gradually decreased or increased according to the slipping condition of the front and rear wheels.

【0095】

Further, although in the shown embodiment the holding pressure Pc of the rear wheels is variably set according to the vehicle speed V and the deceleration Gxb of the vehicle in steps 30 and 40, the holding pressure Pc of the rear wheels may be variably set according to only one of the vehicle speed V and the deceleration Gxb of the vehicle, and further the holding pressure Pc of the rear wheels may be set at a constant value not to be varied according to the vehicle speed V and the deceleration Gxb of the vehicle.

【0096】

Further, although in the shown embodiment the holding pressure Pc of the rear wheels is calculated in steps 100-110 based upon the vehicle speed V by taking the braking effectiveness coefficient of the braking force generation means into consideration, the modification of the holding pressure Pc of the rear wheels based upon the variation of the braking effectiveness coefficient

may be omitted.

【0097】

Further, although in the shown embodiment the front left and right wheels and the rear left and right wheels are controlled to be the same pressure with one another during the front and rear braking force distribution control, the braking pressures of the front left and right wheels or the braking pressures of the rear left and right wheels may be modified to be different from one another according to a turning condition or the behavior of the vehicle.

【0098】

Further, although in the shown embodiment the front left and right wheels and the rear left and right wheels are controlled by separate systems each forming a single system so that the braking pressure is principally controlled by the communication valves 22F and 22R, the braking device to which the present invention is applied may be of any other construction known in this art, provided that the braking pressure of the front wheels can be increased to be higher than the master cylinder pressure, while the braking pressure of the rear wheels can be controlled to be lower than the master cylinder pressure.

【Brief description of the drawings】

【Fig. 1】

A diagram showing an embodiment of the oil hydraulic circuit and the electronic control device of the braking control device according to the present invention.

【Fig. 2】

A diagrammatical sectional view showing the communication control valve for the front wheels shown in Fig. 1.

【Fig. 3】

A flowchart showing the braking force distribution control routine for the front and rear wheels according to the shown embodiment.

【Fig. 4】

A graph showing the relationship between vehicle speed V and the basic holding pressure Pcs of the rear wheels.

【Fig. 5】

A graph showing the relationship between deceleration Gxb of the vehicle and the pressure compensation ΔPc for the basic holding pressure Pcs.

【Fig. 6】

A graph showing the relationship between vehicle speed V and the braking effectiveness coefficient BEF.

【Fig. 7】

A graph showing the relationship between an ideal front and rear distribution line and braking pressure Pf of the front wheels and braking pressure Pr of the rear wheels in the shown embodiment.

【Fig. 8】

A graph showing the relationship between the master cylinder pressure Pm and braking pressure Pf of the front wheels and braking pressure Pr of the rear wheels in the shown embodiment.

【Fig. 9】

An illustration diagrammatically showing variations of braking pressures of the front and rear wheels under a simplification of the coefficient Kb to be 1 with respect to the case of the shown embodiment (A) and the case of the conventional braking control device not taking the increment of the braking pressure to be increased by the brake assist control into consideration (B).

【Explanation of the reference numerals】

10 ... braking device

14 ... master cylinder

22F, 22R ... communication control valves

26FL, 26FR, 26RL, 26RR ... wheel cylinders

42F, 42R ... oil pumps

28FL-28RR, 34FL-34RR ... on-off valves

42F, 42R ... pumps

60F, 60R ... inlet control valves

70 ... valve chamber

74 ... valve element

84 ... compression coil spring

88 ... non-return valve

90 ... electronic control device

96 ... pressure sensor

98 ... vehicle speed sensor

100 ... longitudinal acceleration sensor

FIG. 1

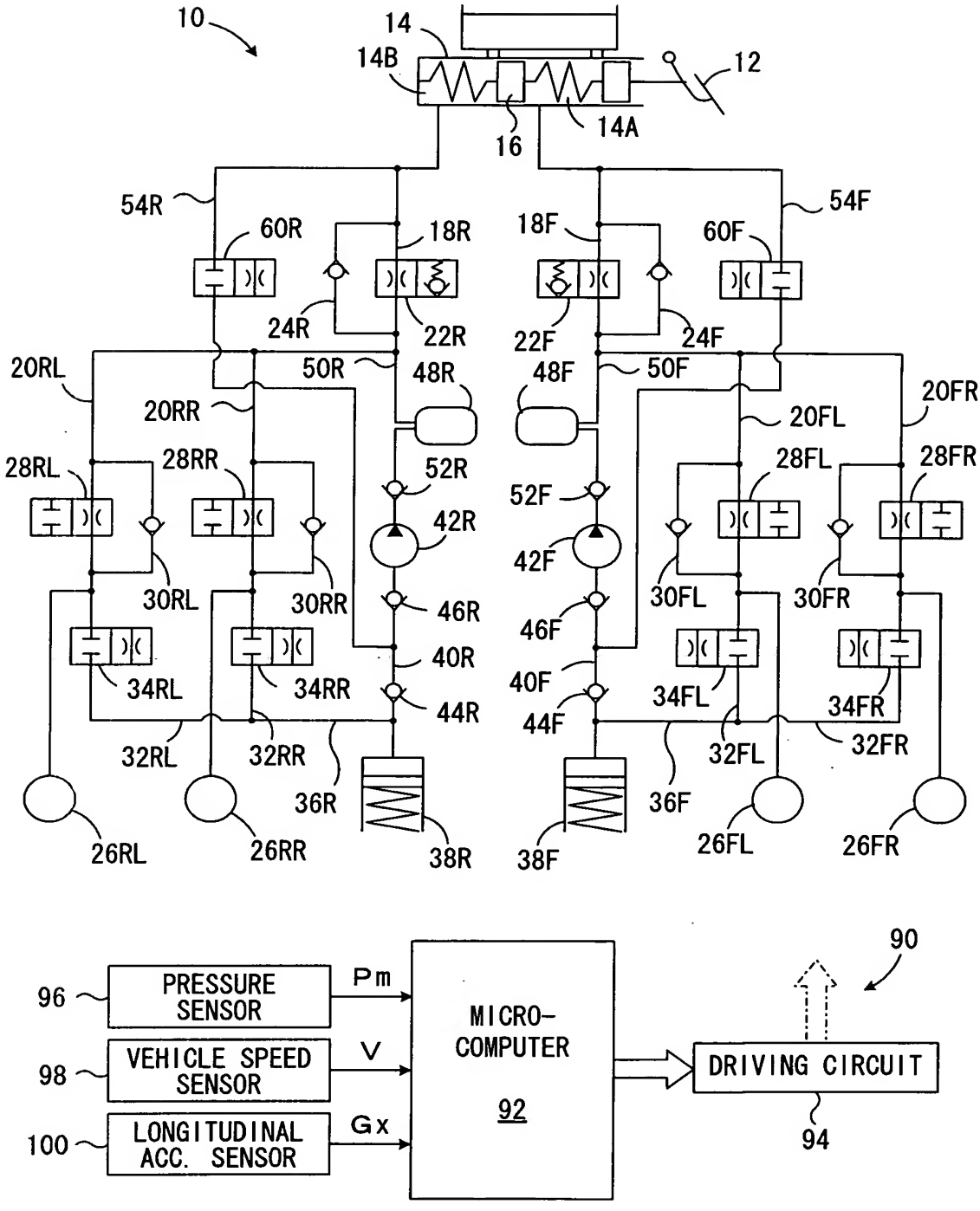


FIG. 2

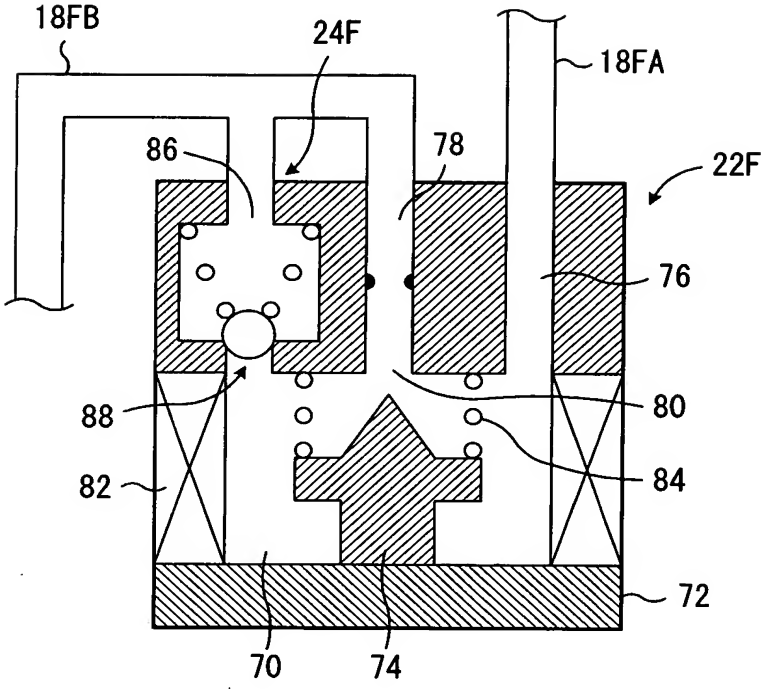


FIG. 3

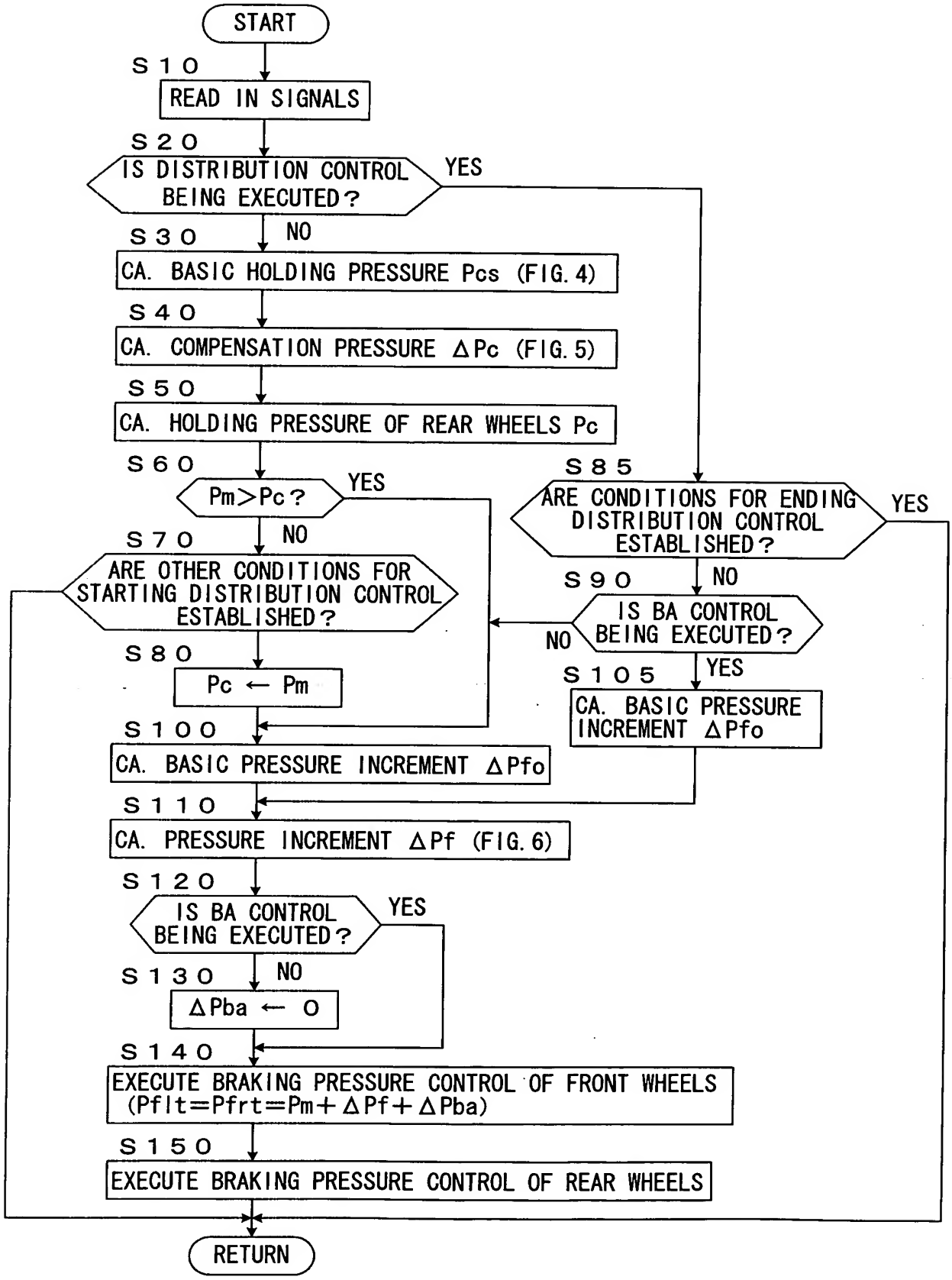

START
S10
READ IN SIGNALS
S20
IS DISTRIBUTION CONTROL BEING EXECUTED?
YES
NO
S30
CA. BASIC HOLDING PRESSURE Pcs (FIG. 4)
S40
CA. COMPENSATION PRESSURE ΔPc (FIG. 5)
S50
CA. HOLDING PRESSURE OF REAR WHEELS Pc
S60
Pm>Pc?
YES
NO
S70
ARE OTHER CONDITIONS FOR STARTING DISTRIBUTION CONTROL ESTABLISHED?
S80
Pc ← Pm
S85
ARE CONDITIONS FOR ENDING DISTRIBUTION CONTROL ESTABLISHED?
YES
S90
NO
IS BA CONTROL BEING EXECUTED?
NO
YES
S105
CA. BASIC PRESSURE INCREMENT ΔPfo
S100
CA. BASIC PRESSURE INCREMENT ΔPfo
S110
CA. PRESSURE INCREMENT ΔPf (FIG. 6)
S120
IS BA CONTROL BEING EXECUTED?
YES
S130
NO
ΔPba ← 0
S140
EXECUTE BRAKING PRESSURE CONTROL OF FRONT WHEELS (Pflt=Pfrt=Pm+ΔPf+ΔPba)
S150
EXECUTE BRAKING PRESSURE CONTROL OF REAR WHEELS
RETURN

FIG. 4

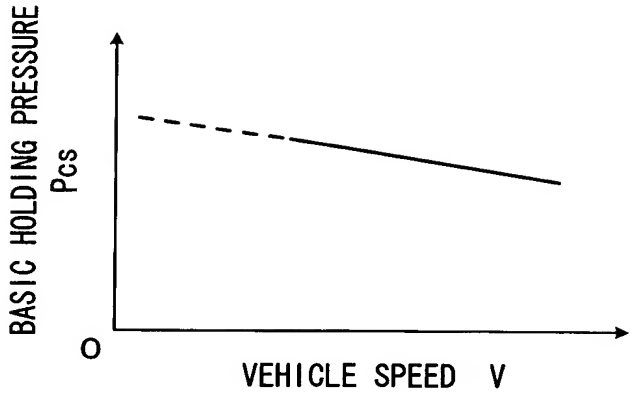


FIG. 5

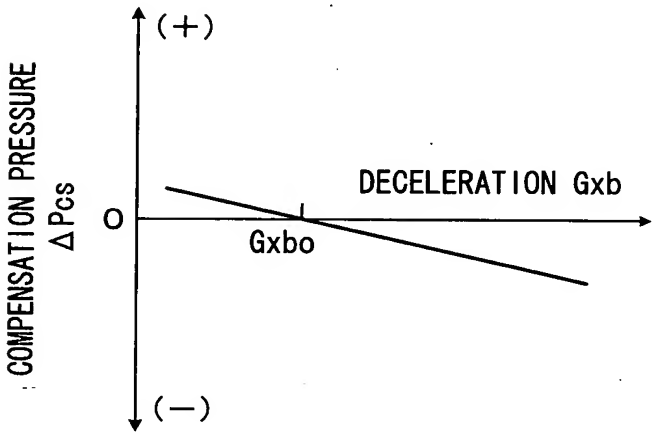


FIG. 6

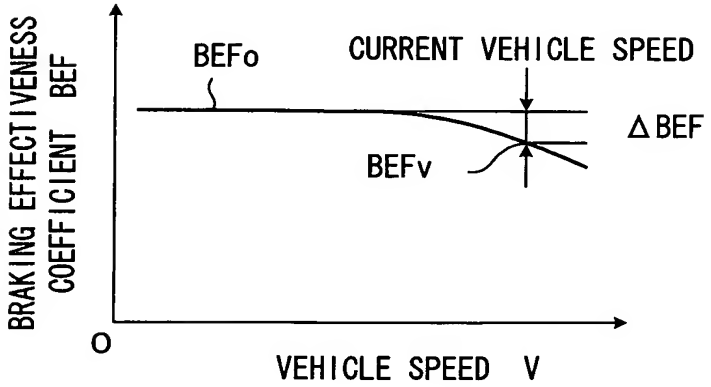


FIG. 7

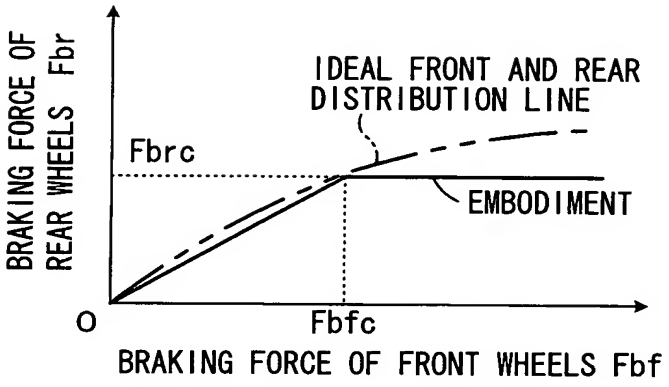

BRAKING FORCE OF REAR WHEELS Fbr
IDEAL FRONT AND REAR DISTRIBUTION LINE
Fbrc
EMBODIMENT
O
Fbfc
BRAKING FORCE OF FRONT WHEELS Fbf

FIG. 8

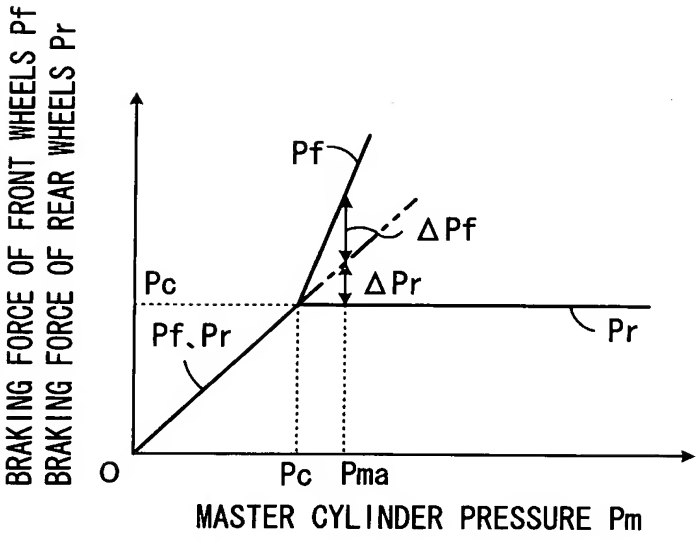
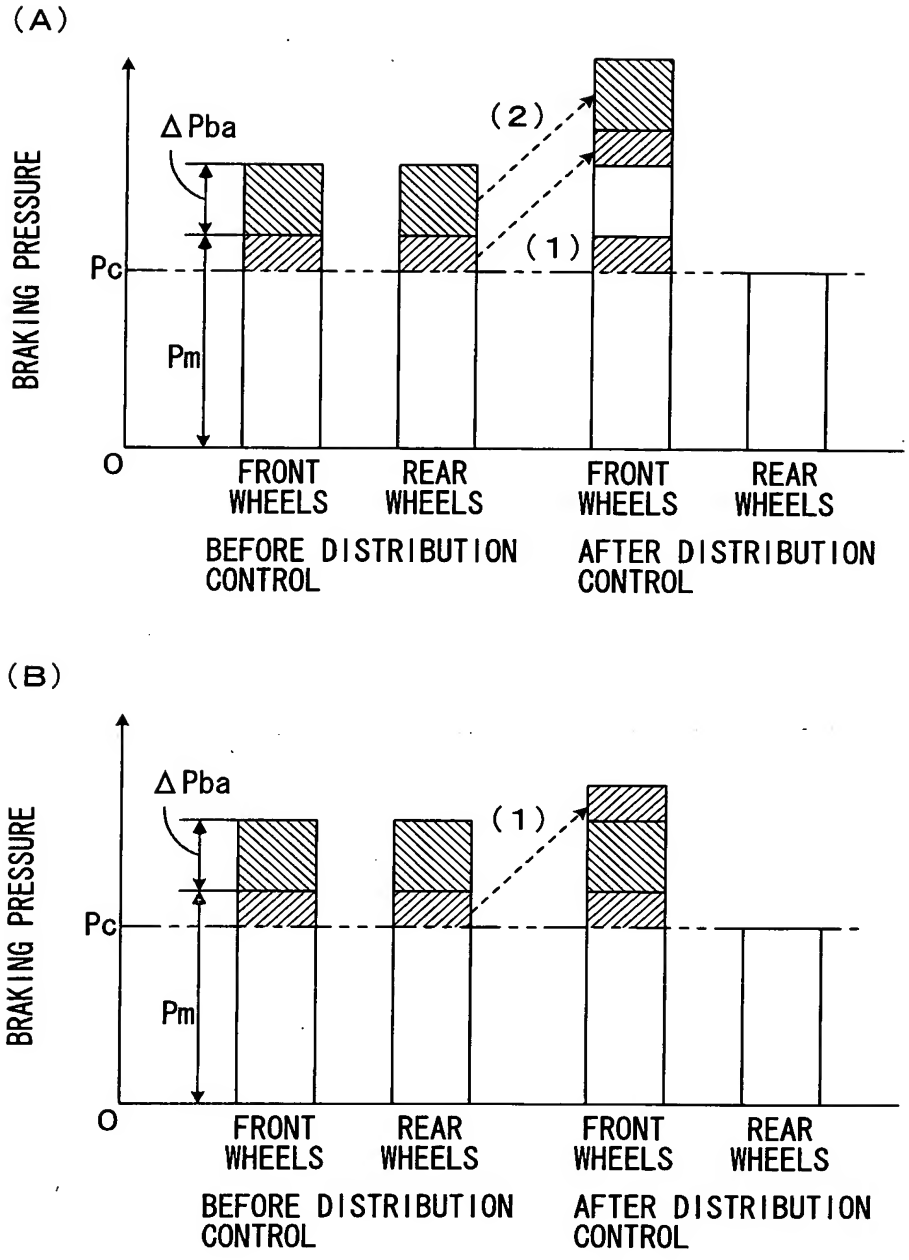

BRAKING FORCE OF FRONT WHEELS Pf
BRAKING FORCE OF REAR WHEELS Pr
Pf
ΔPf
ΔPr
Pc
Pf、Pr
Pr
O
Pc
Pma
MASTER CYLINDER PRESSURE Pm

FIG. 9


(A)
BRAKING PRESSURE
ΔPba
(2)
(1)
Pc
Pm
O
FRONT WHEELS
REAR WHEELS
FRONT WHEELS
REAR WHEELS
BEFORE DISTRIBUTION CONTROL
AFTER DISTRIBUTION CONTROL
(B)
BRAKING PRESSURE
ΔPba
(1)
Pc
Pm
O
FRONT WHEELS
REAR WHEELS
FRONT WHEELS
REAR WHEELS
BEFORE DISTRIBUTION CONTROL
AFTER DISTRIBUTION CONTROL

【Title of the document】 Abstract

【Abstract】

【Object】

To definitely ensure the braking effect of an auxiliary braking control such as a brake assist control while definitely accomplishing the effects of the front and rear braking force distribution control.

【Means to solve the object】

The holding pressure Pc of the rear wheels is calculated (S50-70), and an increment ΔPf of the braking pressure of the front wheels is calculated based upon a difference Pm − Pc between the master cylinder pressure Pm and the holding pressure Pc of the rear wheels (S110), and the braking pressure of the front wheels is controlled to be a sum of Pm and ΔPf (S120) when the brake assist control is not executed (S90), while when the brake assist control is being executed (S90), an increment ΔPf of the braking pressure of the front wheels is calculated based upon a difference Pm + ΔPba − Pc between "master cylinder pressure Pm + increment ΔPba of the braking pressure by the brake assist control" and the holding pressure Pc of the rear wheels (S105), and the braking pressure of the front wheels is controlled to be a sum of Pm, ΔPf and ΔPba (S120), with the braking pressure of the rear wheels being controlled to become the holding pressure Pc (S130).

【Figure elected】 Fig. 3